CLAIMS

WHAT IS CLAIMED IS:

1. An apparatus for preparing a substrate, the apparatus comprising:
an electromagnetic radiation source for generating an active zone, wherein said electromagnetic radiation comprises radiation in the far ultra-violet region and wherein said electromagnetic radiation is directed to impinge on the substrate exposing a surface of the substrate to the active zone whereby the substrate is modified for adhering a material onto the surface of said substrate by exposure to said active zone, and wherein the apparatus operates at substantially ambient pressure.

2. The apparatus of claim 1, wherein said electromagnetic radiation further comprises infra-red radiation.

3. The apparatus of claim 1, wherein said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to about 300 nanometers.

4. The apparatus of claim 1, wherein said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to about 250 nanometers.

5. The apparatus of claim 1, wherein the intensity of said electromagnetic radiation ranges from about 2.0 joules per square centimeter to about 5,000 joules per square centimeter.

6. The apparatus of claim 1, wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter.

7. The apparatus of claim 1, wherein the electromagnetic radiation source is stationary.

8. The apparatus of claim 1, further comprising:
a conveyor system for conveying the substrate through said active zone whereby the substrate is exposed to the active zone for a residence time.

9. The apparatus of claim 8, wherein the residence time is in the range of from about 0.1 seconds to about 10 seconds.

10. The apparatus of claim 8, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds.

11. The apparatus of claim 8, wherein the conveyor system further comprises a conveyor belt for carrying the substrate.

12. The apparatus of claim 8, wherein the conveyor system further comprises a ventilation system for evacuating the active zone adjacent to the conveyor system.

13. The apparatus of claim 1 further comprising an electro-ionization device.

14. The apparatus of claim 13, wherein the electro-ionization device is located in the active zone.

15. The apparatus of claim 13 further comprising a gas supply system for circulating said gas past said electro-ionization device.

16. The apparatus of claim 1 further comprising an infra-red radiation source, wherein the substrate is heated by exposure to said infra-red radiation.

17. The apparatus of claim 16, wherein said infra-red radiation source is located to heat the substrate prior to exposure of said substrate to said electromagnetic radiation source.

18. The apparatus of claim 1 further comprising gas injectors whereby a gas can be injected over the surface of the substrate exposed to the active zone.

19. The apparatus of claim 18, wherein the gas to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

20. The apparatus of claim 1 further comprising a second electromagnetic radiation source, wherein the radiation from said second electromagnetic source comprises radiation in the

far ultra-violet region and wherein the radiation from said second electromagnetic source is directed to impinge on the surface of the substrate exposed to the active zone.

21. The apparatus of claim 1 further comprising a plurality of electromagnetic radiation sources wherein the radiation from each of said plurality of electromagnetic sources comprises radiation in the far ultra-violet region and wherein the radiation from each of said plurality of electromagnetic sources is directed to impinge on the surface of the substrate exposed to the active zone.

22. The apparatus of claim 1, wherein the substrate comprises a plurality of surfaces that lie in more than one plane.

23. The apparatus of claim 22 further comprising means for manipulating the electromagnetic radiation to control the amount of radiation that impinges on each surface.

24. The apparatus of claim 22, wherein the substrate comprises a first surface and a second surface that is inclined relative to the first surface.

25. The apparatus of claim 24, wherein the electromagnetic radiation source is moveably mounted relative to the substrate whereby in one step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the first surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the first surface and in a second step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the second surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the second surface.

26. The apparatus of claim 1, wherein the substrate is comprised of a synthetic polymer.

27. The apparatus of claim 1, wherein the substrate is comprised of a naturally-occurring polymer.

28. The apparatus of claim 1, wherein said material comprises an adhesive.

29. The apparatus of claim 1 further comprising a treatment container for holding the substrate.

30. The apparatus of claim 29, wherein the treatment container further comprises a quartz window.

31. An apparatus for preparing a substrate, the apparatus comprising:
an electromagnetic radiation source for generating an active zone, wherein said electromagnetic radiation is radiation having a wave length in the range of about 150 nanometers to about 250 nanometers, and wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter and wherein said electromagnetic radiation is directed to impinge on the substrate exposing a surface of the substrate to the active zone whereby the substrate is modified for adhering a material onto the surface of said substrate by exposure to the active zone, and
wherein the apparatus operates at substantially ambient pressure.

32. The apparatus of claim 31, wherein said electromagnetic radiation further comprises infra-red radiation.

33. The apparatus of claim 31, wherein the electromagnetic radiation source is stationary.

34. The apparatus of claim 31, further comprising:
a conveyor system for conveying the substrate through said active zone whereby the substrate is exposed to the active zone for a residence time.

35. The apparatus of claim 34, wherein the residence time is in the range of from about 0.1 seconds to about 10 seconds.

36. The apparatus of claim 34, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds.

37. The apparatus of claim 34, wherein the conveyor system further comprises a conveyor belt for carrying the substrate.

38. The apparatus of claim 34, wherein the conveyor system further comprises a ventilation system whereby the active zone adjacent to the conveyor system can be evacuated.

39. The apparatus of claim 31 further comprising an electro-ionization device.

40. The apparatus of claim 39, wherein the electro-ionization device is located in the active zone.

41. The apparatus of claim 39 further comprising a gas supply system for circulating the gas past said electro-ionization device.

42. The apparatus of claim 34 further comprising an infra-red radiation source, wherein the substrate is heated by exposure to said infra-red radiation.

43. The apparatus of claim 42, wherein said infra-red radiation source is located to heat the substrate prior to exposure of said substrate to said electromagnetic radiation source.

44. The apparatus of claim 31 further comprising gas injectors whereby a gas can be injected over the surface of the substrate exposed to the active zone.

45. The apparatus of claim 44, wherein the gas to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, chlorine functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

46. The apparatus of claim 31 further comprising a second electromagnetic radiation source, wherein the radiation from said second electromagnetic source comprises radiation in the far ultra-violet region and wherein the radiation from said second electromagnetic source is directed to impinge on the surface of the substrate exposed to the active zone.

47. The apparatus of claim 31 further comprising a plurality of electromagnetic radiation sources wherein the radiation from each of said plurality of electromagnetic sources comprises radiation in the far ultra-violet region and wherein the radiation from each of

said plurality of electromagnetic sources is directed to impinge on the surface of the substrate exposed to the active zone.

48. The apparatus of claim 31, wherein the substrate comprises a plurality of surfaces that lie in more than one plane.

49. The apparatus of claim 48 further comprising means for manipulating the electromagnetic radiation to control the amount of radiation that impinges on each surface.

50. The apparatus of claim 48, wherein the substrate comprises a first surface and a second surface that is inclined relative to the first surface.

51. The apparatus of claim 50, wherein the electromagnetic radiation source is moveably mounted relative to the substrate whereby in one step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the first surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the first surface and in a second step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the second surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the second surface.

52. The apparatus of claim 31, wherein the substrate is comprised of a synthetic polymer.

53. The apparatus of claim 48, wherein the substrate is comprised of a naturally-occurring polymer.

54. The apparatus of claim 48, wherein said material comprises an adhesive.

55. The apparatus of claim 48 further comprising a treatment container for holding the substrate.

56. The apparatus of claim 55, wherein the treatment container further comprises a quartz window.

57. An apparatus for preparing a polymer substrate for adhering a material comprising an adhesive onto said polymer substrate, wherein the apparatus operates at substantially ambient pressure, the apparatus comprising:
an electromagnetic radiation source for generating an active zone, wherein said electromagnetic radiation is radiation having a wave length in the range of about 150 nanometers to 250 nanometers, and wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter and wherein said electromagnetic radiation is directed to impinge on the substrate exposing a surface of the substrate to the active zone whereby the substrate is modified for adhering a material onto the surface of said substrate by exposure to the active zone, and
wherein the apparatus operates at substantially ambient pressure
a conveyor system for conveying the substrate through said active zone whereby the substrate is exposed to the active zone for a residence time, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds;
a ventilation system whereby the active zone adjacent to the conveyor system can be evacuated;
an electro-ionization device;
an air supply system for circulating air past said electro-ionization device;
an infra-red radiation source; and
a gas injector system whereby a gas can be injected over the surface of the substrate exposed to the active zone.

58. The apparatus of claim 57, wherein said infra-red radiation source is located to heat the substrate prior to exposure of said substrate to said electromagnetic radiation source.

59. The apparatus of claim 57, wherein the gas to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

60. The apparatus of claim 57, further comprising a second electromagnetic radiation source, wherein the radiation from said second electromagnetic source comprises radiation in the far ultra-violet region and wherein the radiation from said second electromagnetic source is directed to impinge on the surface of the substrate exposed to the active zone.

61. The apparatus of claim 57, further comprising a plurality of electromagnetic radiation sources wherein the radiation from each of said plurality of electromagnetic sources comprises radiation in the far ultra-violet region and wherein the radiation from each of said plurality of electromagnetic sources is directed to impinge on the surface of the substrate exposed to the active zone.

62. The apparatus of claim 57, wherein the substrate comprises a plurality of surfaces that lie in more than one plane.

63. The apparatus of claim 62 further comprising means for manipulating the electromagnetic radiation source to control the amount of radiation that impinges on each surface.

64. The apparatus of claim 62, wherein the substrate comprises a first surface and a second surface that is inclined relative to the first surface.

65. The apparatus of claim 64, wherein the electromagnetic radiation source is moveably mounted relative to the substrate whereby in one step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the first surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the first surface and in a second step said electromagnetic radiation source can be moved relative to the substrate to cause the electromagnetic radiation to be incident on the second surface at an angle of about 15 degrees to about 75 degrees with respect to the normal plane of the second surface.

66. The apparatus of claim 57, wherein the substrate is comprised of a synthetic polymer.

67. The apparatus of claim 57, wherein the substrate is comprised of a naturally-occurring polymer.

68. An apparatus for fabricating a shoe having at least one sole, the apparatus comprising:
an electromagnetic radiation source for generating an active zone, wherein said electromagnetic radiation comprises radiation in the far ultra-violet region and wherein said electromagnetic radiation is directed to impinge on the sole exposing a surface of the sole to the active zone whereby the sole is modified for adhering a material onto the surface of said sole, and
wherein the apparatus operates at substantially ambient pressure.

69. The apparatus of claim 68, wherein said electromagnetic radiation further comprises infra-red radiation.

70. The apparatus of claim 68, wherein of said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to 300 nanometers.

71. The apparatus of claim 68, wherein of said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to 250 nanometers.

72. The apparatus of claim 68, wherein the intensity of said electromagnetic radiation ranges from about 2.0 joules per square centimeter to about 5,000 joules per square centimeter.

73. The apparatus of claim 68, wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter.

74. The apparatus of claim 68, wherein the electromagnetic radiation source is stationary.

75. The apparatus of claim 68, further comprising:
a conveyor system for conveying the substrate through said active zone whereby the substrate is exposed to the active zone for a residence time.

76. The apparatus of claim 75, wherein the residence time is in the range of from about 0.1 seconds to about 10 seconds.

77. The apparatus of claim 75, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds.

78. The apparatus of claim 75, wherein the conveyor system further comprises a conveyor belt for carrying the sole.

79. The apparatus of claim 75, wherein the conveyor system further comprises a ventilation system for evacuating the active zone adjacent to the conveyor system.

80. The apparatus of claim 68 further comprising an electro-ionization device.

81. The apparatus of claim 80, wherein the electro-ionization device is located in the active zone.

82. The apparatus of claim 80 further comprising an air supply system for circulating air past said electro-ionization device.

83. The apparatus of claim 68 further comprising an infra-red radiation source, wherein the sole is heated by exposure to said infra-red radiation.

84. The apparatus of claim 83, wherein said infra-red radiation source is located to heat the sole prior to exposure of said sole to said electromagnetic radiation source.

85. The apparatus of claim 68 further comprising gas injectors whereby a gas can be injected over the surface of the sole exposed to the active zone.

86. The apparatus of claim 85, wherein the gas to be injected over the surface of the sole exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

87. The apparatus of claim 68 further comprising a second electromagnetic radiation source, wherein the radiation from said second electromagnetic source comprises radiation in the far ultra-violet region and wherein the radiation from said second electromagnetic source is directed to impinge on the surface of the sole exposed to the active zone.

88. The apparatus of claim 68 further comprising a plurality of electromagnetic radiation sources wherein the radiation from each of said plurality of electromagnetic sources comprises radiation in the far ultra-violet region and wherein the radiation from each of said plurality of electromagnetic sources is directed to impinge on the surface of the sole exposed to the active zone.

89. The apparatus of claim 68, wherein the sole is comprised of a synthetic polymer.

90. The apparatus of claim 68, wherein the sole is comprised of a naturally-occurring polymer.

91. The apparatus of claim 68, wherein said material comprises an adhesive.

92. A method for preparing a substrate, the method comprising:
generating an active zone using an electromagnetic radiation source; and
exposing said substrate to the active zone whereby the substrate is modified for adhering a material comprising an adhesive onto said substrate by exposure to the active zone, and wherein the method is performed at substantially ambient pressure.

93. The method of claim 92, wherein the substrate comprises a polymer.

94. The method of claim 92, wherein said substrate comprises a sole of a shoe.

95. The method of claim 92, wherein said substrate comprises a composite used in aircraft and space vehicle fabrication.

96. The method of claim 92, wherein said substrate comprises a component used in automobile manufacturing.

97. The method of claim 92, wherein said substrate comprises a well-plate, wherein said well-plate is used for biochemical analysis.

98. The method of claim 92, wherein said electromagnetic radiation further comprises infra-red radiation.

99. The method of claim 92, wherein of said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to 300 nanometers.

100. The method of claim 92, wherein of said electromagnetic radiation comprises radiation having a wave length in the range of about 150 nanometers to 250 nanometers.

101. The method of claim 92, wherein the intensity of said electromagnetic radiation ranges from about 2.0 joules per square centimeter to about 5,000 joules per square centimeter.

102. The method of claim 92, wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter.

103. The method of claim 92, further comprising:
conveying the substrate through said active zone using a conveyor system whereby the substrate is exposed to the active zone for a residence time.

104. The method of claim 103, wherein the residence time is in the range of from about 0.1 seconds to about 10 seconds.

105. The method of claim 103, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds.

106. The method of claim 103, wherein the conveyor system further comprises a conveyor belt for carrying the substrate.

107. The method of claim 103, further comprising:
evacuating the active zone adjacent to the conveyor system.

108. The method of claim 92 further comprising:
exposing the substrate to a discharge from an electro-ionization device.

109. The method of claim 108, wherein the electro-ionization device is located in the active zone.

110. The method of claim 108 further comprising:
circulating a gas past said electro-ionization device so that said gas flows over the electro-ionization device onto the substrate.

111. The method of claim 103 further comprising:
exposing the substrate to an infra-red radiation source, wherein the substrate is heated by exposure to said infra-red radiation.

112. The method of claim 111, wherein the step of exposing the substrate to said infra-red radiation source is performed prior to the step of exposing said substrate to the active zone.

113. The method of claim 92, further comprising:
injecting a gas over the surface of the substrate exposed to the active zone.

114. The method of claim 113, wherein the gas to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

115. A method for preparing a polymer substrate, the method comprising:
generating an active zone at substantially atmospheric pressure using an electromagnetic radiation source, wherein said electromagnetic radiation is radiation having a wave length in the range of about 150 nanometers to 250 nanometers, and wherein the intensity of said electromagnetic radiation ranges from about 10 joules per square centimeter to about 1000 joules per square centimeter whereby the polymer substrate is modified for adhering a material comprising an adhesive onto said polymer substrate by exposure to said active zone;
conveying the substrate through said active zone whereby the substrate is exposed to the active zone for a residence time, wherein the residence time is in the range of from about 0.2 seconds to about 5 seconds;
evacuating the active zone adjacent to the conveyor system;

exposing the surface to an electro-ionization device;
circulating a first gas stream past said electro-ionization device so that the first gas stream flows past the electro-ionization device and onto the surface;
exposing the surface to an infra-red radiation source; and
injecting a second gas stream over the surface of the substrate.

116. The method of claim 115, wherein the step of exposing the substrate to said infra-red radiation source is performed prior to the step of exposing said substrate to the active zone.

117. The method of claim 115, wherein the gas of the first gas stream to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

118. The method of claim 115, wherein the gas of the second gas stream to be injected over the surface of the substrate exposed to the active zone comprises a gas selected from the group consisting of carbon tetrachloride, chloroform, halogen functionality compounds, oxygen functionality compounds, water vapor, oxygen, air, silanes, amine functionality compounds, ammonia, and nitrogen.

119. The method of claim 115, wherein the substrate is comprised of a synthetic polymer.

120. The method of claim 115, wherein the substrate is comprised of a naturally-occurring polymer.